Linking Plant Stress Amelioration to Root Bacteria; Role of Soil pH

Rosa E. Raudales and Brian B. McSpadden Gardener
Department of Plant Pathology, The Ohio State University-OARDC, Wooster, OH.
raudales.1@osu.edu

Abstract

Soil pH can impact plant growth and development, but its impact on biocontrol microbes remains a mystery. Patches with different plant heights were observed in three different sites of an experimental corn field. Interestingly, in this plot plants inoculated with *phlD+* pseudomonads seemed to ameliorate the stress caused by low pH in the soil. As a first step to further investigate the relationships between soil chemistry, plant stress, and root colonization by *phlD+* bacteria, we sampled this field soil and determined likely causes of the observed stresses. To more fully understand the cause of height disparity of non-inoculated plants, soils were collected from subplots that had the tallest (A), intermediate height (B), and the shortest plants (C) and then were sown with corn in a greenhouse pot assay. Plants grown in soil A had higher fresh shoot weight and growth stage compared to plants grown in soils B and C ($p \leq 0.018$). All soils were confirmed to have pH in the range of *strongly acid*; nonetheless, significant differences were observed in nutrient uptake and nutrient availability. Soil C had the lowest pH magnesium (Mg) and calcium (Ca) and the highest levels of manganese in the soil and the tissue ($p \leq 0.011$ for all). This study reveals the variable plant growth responses that lie under a narrow pH range within a limited space. This information will be used for further research on corn stress caused by low pH and its amelioration by native and inoculated populations of *phlD+* pseudomonads**.**

Introduction

In May 2006, a field trial was established with the purpose to make a comparison between biological (DAPG-producers pseudomonads strain Wood1R) and chemical seed treatments. Unexpectedly, patches with different height were observed. Interestingly, within patches clear differences were observed between plants that were inoculated with Wood1R and non-inoculated (fig1).This evidence suggested that DAPG- producing pseudomonads alleviate the stress caused by low pH in the soil. Therefore, as a first step to further investigate the relationships between soil chemistry, plant stress, and root colonization by *phlD+* bacteria, we sampled this field soil and determined likely causes of the observed stresses.

Fig 1. Differential growth observed under low pH soil between corn treated with DAPG-producers (strain Wood1R) and the untreated corn.

Objective

- Identify the soil chemistry factors that have an effect on plant vigor (e.g. fresh shoot weight (FSW) growth stage (GS) and Horsfall and Barrat (HB) Rating) under low pH conditions.

Materials and Methods

- Soil from three non-inoculated sites were collected. The three sites contained plants with three height levels; tallest (A), intermediate (B) and shortest (C).
- The soils were sown with corn cultivar SC1091 in 4"pots.
- Growth stage (GS) and fresh shoot weight (FSW) measurements were taken 19 and 32 days pos planting.
- The HB rating system, which is used to rate the severity of disease (Horsfall and Barratt, 1945), was used to rate the amount of white leaf streak.

Fig 2. White streak symptoms of corn seedlings in Soil C

- Soil (S-) and plant tissue (PT-) were collected for nutrient analysis

Results

- Soil A had the plants with the highest GS and FSW. (table 1 and fig3)
- White stripes were observed on all the treatments; nonetheless, the plants grown in soil C had the most stripes (table 1)
- Growth differential was influenced by the soil pH. All pHs belong to the category of strongly acid. (Taiz and Zeiger, 2006)

Table1. Mean Values for Vigor Measurements

	Vigor Measurements		
Soil	**GS**	**FSW**	**HB**
A	5.88 b	5.35 b	0.19 b
B	4.67 a	3.84 ab	0.67 b
C	5.00 a	2.52 a	7.69 a
P value	0.003	0.018	0.027

LSD Mean separation

- HB rating was positively correlated to the amount of Mn uptake in plants of the three soils. In addition, the levels of Mn in all three soils were above the ideal value. Moreover, HB negatively correlated with soil variables (pH, Ca and Mg) (table 2)
- Correlation analysis with GS, and ANOVA confirmed that plants grown in soil C had a low Mg concentration (Pearson correlation 0.778 and *P*-value≤0.039) and low concentration of Ca. (table 3)

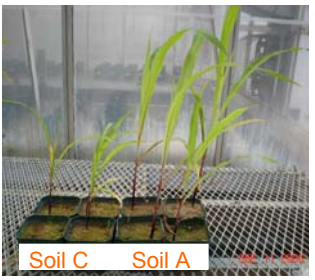

Fig 3. Growth differential of plants grown in Soil A and C.

Table 2. Correlations between HB rating and soil and plant variables. (Pearson Correlation/ P-value)

	HB rating		
	A	**B**	**C**
S-pH	-0.673 0.067	-0.915 0.010	-0.760 0.047
S-Ca	-0.711 0.048	-0.908 0.012	0.012 0.980
S-Mg	-0.673 0.068	-0.918 0.010	-0.081 0.862
PT-Mn	0.974 0.000	0.993 0.000	0.878 0.009

Table 3. Mean values for soil (S-) and plant (PT-) nutrient under soils with different pHs.

		µg/g		
Soil Type	**S-pH**	**PT-Mn**	**S-Ca**	**S-Mg**
A	5.27 a	482.78 b	508.25 a	69.25 a
B	5.49 a	813.63 b	479.00 a	83.00 a
C	4.72 b	2686.02 a	125.63 b	17.88 b
P value	0.000	0.000	0.000	0.000
Ideal value	6-7	20-150*	200**	50**

LSD Mean separation

*Ohio Agronomy Guide **Tri-State Fertilizer Recommendations

Conclusions

- The differential growth observed in the field was reproduced in the greenhouse.
- The height disparity observed was related to low pH in the soil.
- While Ca and Mg were deficient in the soil; Mn uptake reached excessive levels of toxicity.
- Mn toxicity was responsible for the white streak symptoms in the leaves.
- There was a variable plant response under a narrow range of pH.
- This study is the base for further approaches to investigate the relationships between soil chemistry, plant stress, and root colonization by *phlD+* bacteria. These results describe how low pH affects corn's plant health. Therefore, it serves as a reference for identification of possible mechanisms by which DAPG-producer pseudomonads might relieve the stress.

References

- **Horsfall J. G. and Barratt R. W.** An improved grading system for measuring plant diseases. (Abstract.) *Phytopathology* 35:655. 1945.
- **Johnson, J.W., Vitosh, M. L., Mengel, D.B**.Tri-State Fertilizer Recommendations for Corn, Wheat and Alfalfa. Bulletin E-2567. http://ohioline.osu.edu/e2567/index.html
- The Ohio Agronomy Guide. 14th Edition.Bulletin 472.
- **Taiz, L. and Zeiger, E.** Plant Physiology.4th ed. Sunderland: Sinauer Associates.2006.